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EFFECTS OF LOW TEMPERATURES DURING THE WINTER OF 1932 - 33 UPON PINE BEETLE POPULATIONS IN CALIFORNIA

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EFFECTS OF LOW TEMPERATURES DURING THE WINTER OF 1932-33 UPON PINE BEETLE POPULATIONS IN CALIFORNIA.

That extreme cold weather may at times cause high mortality of barkbeetle populations in their overwintering condition, was convincingly demonstrated in certain forest areas of the western United States by the winter of 1932-33. Studies of the effects of this severe winter in California forest areas, which were conducted during the past year by the U. S. Forest Service and Bureau of Entomoligy, have shown that pine beetle epidemics in northwestern California were given a severe though temporary setback as a result of extreme low temperatures.

The first cold spell of the winter to cause killing of these insect populations occurred during the period from December 8 - 15, 1932. A cold wave originating in Wyoming and Montana, moved in a southwesterly direction across southern Idaho, eastern Oregon and reached into northeastern California. This period was marked by long duration of the low temperatures rather than their extreme minima. In February, 1933, another cold spell brought record breaking low temperatures in many western localities, an all-time low of -66° Fahr., being recorded at West Yellowstone. In northern California, however, this February cold spell was of shorter duration and less severity than the one which occurred in the preceding December.

In the lodgepole pine forests of Montana and Wyoming, a very high kill of the overwintering broods of the mountain pine beetle was found following these two periods of cold. In some areas the only insects which survived were those under the bark near the base of the trees where they were covered by the snow level. The mortality of the mountain pine beetle in these northern forests, was found to average from 72.4% on the Targhee National Forest to 98.2% on the Gallatin. In the Ochoco National Forest in eastern Oregon the mortality of the western pine beetle was found to range from 33 to 92 percent of the overwintering broods. Similar mortalities for the same species of barkbeetle were found in the Ponderosa pine areas of Modoc, Siskiyou and Lassen counties in California. However, on the western slopes of the Sierra Nevada range and throughout the central and southern forests of California, the low temperatures reached during the winter had no appreciable effect upon pine beetle populations.

Investigations of 1932-33 Freeze in California

The advent of cold wave in December, 1932, aroused immediate interest as to its possible effect upon bark beetle populations, particularly that of the western pine beetle (Dendroctonus brevicomis, Lec.). Several large control projects were under way at the time in northern California, and the advisability of continuing them was open to question in case a high percent of the beetle population

had been killed by the cold. From what had already been learned in regard to killing temperatures for the western pine beetle, i.e., that the insects are killed when the bark is chilled from 0 - 10 Fahr., it was obvious from weather records that critical temperatures had been reached in the field. A hurried checkup of conditions on the control areas was at once made by the Bureau of Entomology, and in one project on the Modoc National Forest, it was found that at least 65 percent of the beetle population had been killed. Control work on this particular project was therefore discontinued.

With the organization of the CCC program in the spring of 1933, the opportunity was available to use this labor for necessary forest protection work, including barkbeetle control. The extent to which forest insect epidemics within the state had been reduced by the killing cold waves of the preceding winter, became a question of paramount importance. Had the pine beetle population been reduced in certain areas to such extent that control work would be unnecessary during the 1933 season? Where epidemics had been set back by the freeze, would the effect be lasting, or would the beetles rapidly build back their numbers so that the benefits would be nullified within a season or two? To answer these points, arrangements were made by the Forest Service to carry on a comprehensive survey of the more valuable timber stands as a basis for planning insect control projects to be undertaken by the CCC organization.

This survey was directed by the Bureau of Entomology and was carried out by the facilitating personnel of the CCC camps. It included a rough approximation of the zone affected by killing temperatures and the role of the freeze in limiting the barkbeetle population during the season of 1933. The project employed a group of approximately 24 foresters and entomologists from June to October, and was directed largely toward the following objectives:

1. Extent of area in which the overwintering barkbeetle broods were killed as a result of low temperatures.

2. The amount of mortality through the affected zone immediately following the cold spells.

3. The ultimate survival in the spring of 1933, representing those beetles which survived not only the freeze but other unfavorable factors during the winter.

4. Recovery of the beetle population, beginning with the attack by the survivors of the winter freeze and the increase of their progeny up to the fall of 1933.

The methods followed in this work consisted of working sample strips and plots on which the bark of all trees containing overwintering broods, was examined to determine the percent of mortality. Cruises of the same plots were also made at intervals throughout the season to determine the volume of infestation for each succeeding generation of beetles following the emergence of survivors.

Areas in which Winter Mortality Occurred.

Attached to this report is an outline map of California showing the approximate area in the northern part of the state in which appreciable winter kill of the pine beetles was recorded. This map also shows the more important minimum low temperatures for the winter of 1932-33 recorded at weather stations both inside and outside of the mortality zone.

The cold wave of December 8 - 15, 1932, accompanied by a strong wind from the northeast, was most severe in its effect upon the flat Lava country in the northeastern part of the state. The cold apparently lost its intensity as it crossed to the west of the main summits, and very little mortality was found in the drainages toward the Sacramento Valley. The kill extended south along the eastern slopes nearly to Lake Tahoe. The line shown on the map beginning near Hornbrooke on the California-Oregon line and extendingin a southeasterly direction through Burney Valley, Lassen National Park, Westwood and Sierraville, roughly approximates the southwestern limits of the area in which winter kill of the western pine beetle occurred.

Amount of Beetle Mortality in Zone Affected By Killing Temperatures.

Within this zone of killing temperatures, very wide variation was found in the percent of mortality. Certain local areas showed practically 100 percent mortality in all trees; other areas contained trees with all degrees of mortality, ranging from 10 percent to 100 percent. Causes for the partial brood mortality found can be attributed to the fact that the bark was chilled down only to the higher temperatures within the critical range from 2.5° to -7.5° Fahr., and that it did not reach the highly lethal temperatures around -10 degrees and below, where all individuals of the brood are killed. Various factors influence the points to which the bark is cooled. Of first importance is the rate of cooling of the surrounding air, and the duration of minimum temperatures. This factor is determined by weather conditions, elevation, topography, air drainage and wind movements. Within the tree itself, insulation of the broods due to bark thickness and texture is an important variable affecting mortality of the broods. Only when the surrounding air becomes cold enough to compensate for all variables, which is usually around -20°Fahr., does complete mortality occur. If the cold is not severe enough to chill the bark down to a few degrees above zero, no mortality results.

In general, sampling from fifteen separate areas indicated that the mortality following both the December and February cold periods, amounted to 65 percent on the Modoc National Forest; 80 percent on the eastern part of the Klamath; 30 percent on the Shasta and eastern Plumas, and 40-45 percent on the eastern Lassen.

Ultimate Survival as Represented by Emergence of Beetles in the Spring of 1933.

The barkbeetle broods of larvae which survived the two cold periods of this winter, representing 20 to 70 percent of the population, were by no means ready to emerge and attack new trees. They had yet to remain in the bark and complete their development to adults, emerging in late May and June. During this period they were subject to the many factors that produce the normal mortality of broods such as insect enemies, birds and unfavorable moisture conditions in the bark, all of which took their toll and added to the mortality produced by the cold.

The ultimate survival for the winter was determined during the course of summer survey work largely through the aid of facilitating personnel of the CCC organization. The method consisted of counting the number of exit holes in the bark on sample areas. It was found that about 15 percent more of the brood had died between the last cold spell in February and the emergence period in May and June. The total winter mortality on the Modoc was placed as high as 80 percent with corresponding increases on the other National Forests that were studied.

Recovery of Barkbeetle Populations During the Season of 1933.

In the northern California areas, the survivors of the winter broods of the western pine beetle, emerged as new adults in May and early June, 1933. In numbers, the population was greatly weakened from that which had attacked upon the area in the fall of 1932. In Modoc area for example, it was estimated that from each ten trees attacked in the fall of 1932, the effective emergence in the spring of 1933 amounted to no more than the normal number of beetles which would emerge from two trees.

This low ebb of beetle population was reflected by the character of the new attacks of the first seasonal generation which occurred on the area during June and early July. There was no concentration of attacks or grouping of trees, such as occurs when the beetles are abundant. Most of the attacks were scattered and in weakened trees such as those previously top-killed or injured. Another feature of this first 1933 generation was the spreading of the attacks of fewer beetles over a greater bark surface area; i.e., instead of the normal attack of twenty to forty beetles per square foot of bark surface, only about ten to twenty established egg-galleries in the same amount of bark area. These light attacks are successful only in weakened or slow growing trees.

The first seasonal generation of 1933 produced an abundant progeny regardless of the weakened character of the initial attack. In August the attack of the second seasonal generation was under way. This attack displayed much more aggressive tendencies than that of the first seasonal generation. The beetles were attacking stronger trees and there was greater concentration of beetles according to bark surface.

A partial third generation attacked in October and this, together with successful re-attacks by parent adults emerging from infested trees, built up a very formidable infestation by the fall of 1933. On the Modoc area, it was estimated that for each ten trees of the overwintering generation of 1932, nine trees represented the overwintering generation of 1933. Within one season, the beetles had built back in numbers to 90 percent of the population which had suffered an 80 percent mortality during the winter.

It should be made clear, however, that this remarkable recovery was much more evident on the poor site, eastside Ponderosa pine stands than elsewhere in the freeze areas. At least two factors aided and abetted the western pine beetle in its comeback on these areas. One of these was the aggressive character of the pine flat head infestation (Melanophila Sp.). This insect was less severely affected by the freeze than the western pine beetle, and on the poorer sites of the Modoc, it constituted a very high percent of the 1933 infestations. Its attacks upon the tops of slow growing trees put them in a highly favorable condition for the western pine beetle, and much of the 1933 loss was accomplished by the two insects working together. Another factor was the very slow growing condition of these east side stands. The growth rate of the majority of the mature trees had been slowing down for the past fifteen years, making these stands highly susceptible to barkbeetle epidemics. In the west side forests of the state where growth conditions were more favorable in 1933, no such tendency toward increasing infestations was observed during the season, but instead some reduction as a result of natural factors, occurred.

On the whole the evidence is convincing that the extreme cold weather during the winter of 1932-33 was of positive benefit to forest areas in northern California, as its killing effect upon barkbeetle populations appreciably checked timber losses during the ensuing season of 1933. Although the setback to the infestations was of temporary duration, the volume of timber killed would have been much greater if the freeze had not occurred. To this extent at least the record breaking cold winter has compensated for the damage that it did to orchards, shade trees and certain agricultural crops in the northern valleys of California.

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Berkeley, California,
April 10, 1934.

OUTLINE MAP OF NORTHERN CALIFORNIA SHOWING NATIONAL FOREST AND PARK BOUNDARIES

SCALE: 37 mi. = 1 in.

APPROXIMATE AREA WHERE pine beetle MORTALITY OCCURRED DURING THE WINTER OF 1932 - 1933.

(F°) MINIMUM TEMPERATURES RECORDED AT WEATHER STATIONS WITHIN THE PONDEROSA PINE BELT.

OREGON
CALIFORNIA
NEVADA
CALIFORNIA
PACIFIC OCEAN
Crescent City
Eureka
Klamath Falls
Malin
Lakeview
Yreka
Mt. Shasta City
Weaverville
Redding
Red Bluff
Chico
Willows
Willitts
Clear L.
Lower Klamath L.
Tule L.
Clear L.
Goose L.
Upper L.
Middle L.
Lower L.
Hackamore
Alturas
Fall River Mills
Madeline
Eagle L.
Susanville
Mineral
Westwood
Honey L.
Doyle
Quincy
Portola
Bowman Dam
Sierraville
Spaulding L.
Nevada City
Marysville
Tahoe
Lake Tahoe
Placerville
SACRAMENTO
Santa Rosa
Muir Woods Nat'l. Mon.
Farallon Is.
Berkeley
Oakland
San Francisco
San Jose
Merced
Madera
Fresno
Salinas
Stockton
Sonora
Yosemite
Mono L.
Northfork
Huntington L.
Bishop
Owens L.
Porterville
Tulare L.
Bakersfield
Buena Vista L.
Kern L.
San Luis Obispo
General Grant Nat'l. Park
Sequoia Nat'l. Park
Lassen Volcanic Nat. Park
KLAMATH NATIONAL FOREST
SHASTA NATIONAL FOREST
TRINITY NAT'L. FOREST
MENDOCINO NAT'L. FOREST
LASSEN NAT'L. FOREST
MODOC NATIONAL FOREST
PLUMAS NATIONAL FOREST
TAHOE NAT'L. FOREST
ELDORADO NAT'L. FOREST
STANISLAUS NAT'L. FOREST
TUOLUMNE NAT'L. FOREST
YOSEMITE NAT'L. PARK
INYO NAT'L. FOREST
SIERRA NAT'L. FOREST
SEQUOIA NAT'L. PARK
SEQUOIA NAT'L. FOREST
SANTA BARBARA NAT'L. FOR.
MONO NAT'L. FOREST
KLAMATH R.
SALMON R.
TRINITY R.
EEL R.
RUSSIAN R.
SACRAMENTO R.
FEATHER R.
YUBA R.
AMERICAN R.
PIT R.
HAT CR.
PUTA CR.
COSUMNES R.
MOKELUMNE R.
CALAVERAS R.
STANISLAUS R.
TUOLUMNE R.
MERCED R.
SAN JOAQUIN R.
FRESNO R.
KINGS R.
KAWEAH R.
KERN R.
SINK
OWENS R.
SAN JUAN CR.

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EXPLANATION OF CHART SHOWING 1933 SEASONAL DEVELOPMENT OF WESTERN PINE BEETLE

This chart was prepared by Junior Forester R. L. Furniss in order to show graphically the effect of the 1932-33 winter kill upon the infestation in the Modoc National Forest. It also shows the manner in which the western pine beetle increased its numbers during the summer of 1933 after the setback suffered as a result of the freeze.

For the purpose of quantitative comparisons, ten trees are used to represent 100 percent of the overwintering population which went into the overwintering condition in the fall of 1932. As 80 percent of this population was killed between December and May, the 20 percent which survived the winter is represented by two trees.

The new adults developing from the broods in these two trees of survivors, emerged early in June, 1933, and successfully attacked and killed two trees representing the first seasonal generation. Soon after these parent adults had completed egg laying, they left these first two trees and started a second attack. It was found that about 50 percent of these parent adults successfully started the second attack and that they were able to kill another tree in July.

The eggs laid by the parent adults in both the first and second attacks developed broods which emerged as new adults in August and early September. The attack of these new adults composed the main part of the second seasonal generation. From the first trees attacked in August the parent adults also emerged and started a second attack, as was the case in the first generation. Altogether eight trees were attacked during August and September and in seven of them the broods remained until fall and went into the overwintering stage. In the earliest tree attacked in August, however, the broods completed development, emerged in October and started the attack of a third seasonal generation, which also went into the overwintering stage. Quantitatively this October attack is represented by two trees, which added to the seven already containing overwintering brood, makes a total of nine trees entering the winter period in the fall of 1933. Compared with ten trees in the fall of 1932, this shows that in one season the population had recovered to 90 percent of its numbers for the generation preceding the freeze.

1933 SEASONAL DEVELOPMENT OF DENDROCTONUS BREVICOMIS

MODOC N.F. - CALIFORNIA

OVERWINTERING 1932-33 GENERATION	100 Percent of overwintering 1932-33 generation as represented by ten normal brood trees.	Brood, equivalent to infestation in two normal brood trees, survives in spring of 1933 after 80 percent reduction by winter kill.	New adults emerge from overwintering trees and attack two first-generation trees, ⑪ and ⑫.	50 percent of first-generation parent adults reemerge and attack one late first-generation tree, ⑬	Progeny of first-generation trees emerge and attack four second-generation trees; ⑭, ⑮, ⑯ and ⑰.	50 percent of parent adults of second-Generation trees reemerge and attack two late second-generation trees, ㉙ and ㉚. Progeny of reemerged parent adults of first-generation trees emerge and attack two additional late second-generation trees, ㉛ and ㉜.	Progeny of one early second-generation tree emerge and attack two third-generation trees, ㉝ and ㉞.	Development slows down and finally ceases.	Nine trees containing 1933-34 overwintering brood represent a seasonal increase of 350 percent and approximates the original 1932-33 overwintering brood.
FIRST SEASONAL GENERATION-1933									
SECOND SEASONAL GENERATION - 1933									
THIRD SEASONAL GENERATION - 1933 (PARTIAL)									
	WINTER - 1932	MAY-1933	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER

LEGEND:

- Infested Ponderosa Pine Containing Normal Brood
- Infested Ponderosa Pine Containing Brood Killed by the 1932-33 Freeze.

PINE BEETLE BROOD STAGES

- Egg
- Larva
- Pupa
- New Adult
- Parent Adult

R.L.K